A QUANTITATIVE FRAMEWORK TO STUDY MRI RELATED TREATMENT CHANGES IN THE PROSTATE POST-IMRT

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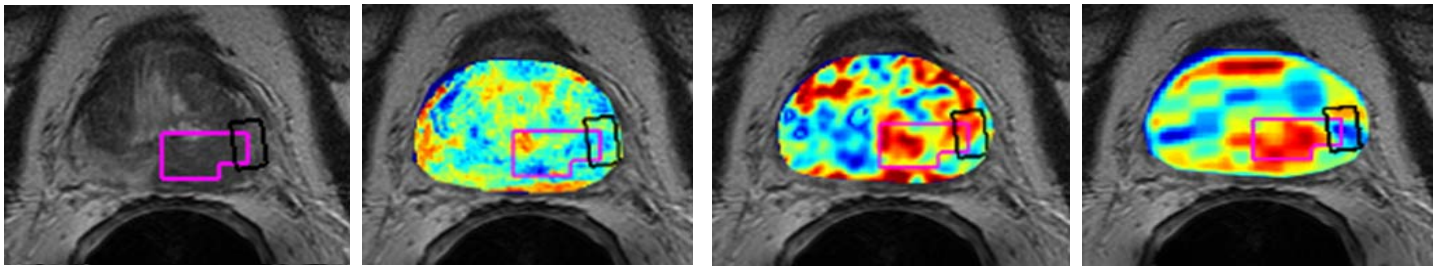
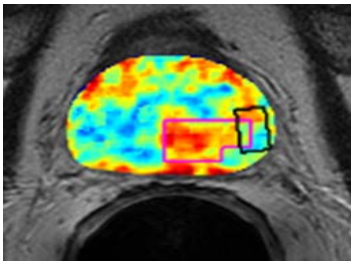
Purpose: In this work, we present an image analysis framework to (a) identify MRI markers obtained via T2-w, DWI, and MRS that correlate the most with treatment changes post-intensity modulated radiation therapy (IMRT) in prostate cancer (CaP) patients [1], and (b) compute a weighted MP-MRI map by optimally combining contributions of strucutral (T2-w), functional (DWI), metabolic (MRS) markers, based on their ability to accurately capturing post-IMRT changes.

Methods and Materials: A total of 14 *in-vivo* endorectal MP-MRI patient datasets were acquired between 1998-2007. All patients underwent external beam IMRT after initial MRI (1.5 Tesla, GE Signa, endorectal coil), with supplementary, neo-adjuvant hormonal therapy. Post-IMRT, patients were reimaged via MP=MRI (3 Tesla, GE Signa, endorectal coil). Ground truth (GT) was defined by an expert (~25 years experience in reading MP-MRI) on a per MRS voxel basis on both pre-, post-IMRT MP-MRI images, by comparison across digital rectal examination findings, pathological biopsy report, presence of focal low-signal intensities on T2w MRI, ADC map, and choline-to-creatine ratios on MRS. Based on the pre-, post-IMRT CaP annotations, regions of definite treatment change were defined on each image as (1) successful treatment (no residual CaP, and no new CaP occurrence), (2) partially successful treatment (residual CaP but no new CaP occurrence), and (3) local recurrence (no residual CaP but new CaP occurrence). After GT generation, in Step 1, pre- and post-IMRT studies are affinely registered on a per-voxel basis via a mutual information based 3D affine registration scheme [2] to register each of T2w, DWI, and MRS protocols. In Step 2, a difference map is obtained by computing the absolute difference of changes in T2-w intensities, ADC values (via DWI), and choline/creatine ratio (via MRS) between pre, and post-IMRT images. A MP-MRI map [3] is then computed in Step 3 by intelligently weighting (via optimization) and combining the contributions of each of the markers in accurately capturing the changes post-IMRT.

Results: When evaluated against the expert delineated biopsy-based GT, a higher mean area under the receiver operating curve (AUC) was obtained via MP-MRI compared to individual MRI difference maps, on a total of 14 MP-MRI patient studies, which reflects that a MP-MRI approach may be more appropriate in evaluating post-IMRT treatment changes.



(a) (b) (c) (d)



(e)

Method	AUC	Accuracy
T2-w	54.5 ± 8.3	54.9 ± 7.8
ADC maps	70.8 ± 7.0	70.2 ± 10.2
Ch/cr ratio	68.6 ± 10.3	67.5 ± 9.0
MP-MRI	73.2 ± 6.9	72.5 ± 8.0

Fig 1: (a) GT shown in magenta (pre-IMRT CaP) and black (post-IMRT CaP). Heat maps in (b), (c), (d) show difference maps for T2 (b), ADC (c), MRS (d) respectively. MP-MRI map is shown in (e). Table demonstrate quantitative results in terms of AUC and accuracy in capturing post-IMRT-related changes.

Conclusion: We presented a quantitative framework that evaluates IMRT-related changes in the prostate using MP-MRI for (1) identifying MRI markers that best capture IMRT-changes, (2) optimally weighting best performing MRI markers to obtain a MP-MRI map that better identifies IMRT-related changes compared to individual protcols, and (3) early identification of residual and recurrent prostate cancer via MP-MRI maps, on a cohort of 14 MP-MRI studies.

References: [1] Chen et al Acta Radiologica (2008) [2] Chappelow et al Med Phy (2011). [3] Tiwari et al NMRB (2011).